

## **Instream Flow Study Methods used in Washington**

The three methods instream flow study methods described below are the primary flow measurement methods used in Washington state. IFIM and toe-width are the methods used most often. Because it is infrequently used in Washington, the Tennant method is omitted from the table.

### **Toe-Width Method**

The Toe-Width Method was developed by the Department of Fisheries (WDF), the Department of Game (WDG), and the U.S. Geological Service (USGS) in the 1970s at the request of the state legislature in response to the need to determine minimum instream flows for fish. After the legislature passed the Minimum Water Flows and Levels law in 1969 and the Water Resources Act of 1971, USGS collected water depths and velocities along transects over known spawning areas. WDF and WDG provided the criteria for salmon and steelhead spawning and rearing and the locations of the known spawning areas. After 9 years of data collection, USGS had measured 28 streams and rivers in eastern and western Washington. They had 84 study reaches with each reach consisting of 4 transects. They measured each transect at 8 to 10 different flows. USGS used the data from these 336 transects to calculate spawning and rearing flows for salmon and steelhead. Criteria for the needed spawning and rearing depths and velocities for each fish species and lifestage were used to calculate the square feet of habitat at each measured flow. These points of habitat quantity at different flows were connected to create a fish habitat versus streamflow relationship. Next, these fish habitat relationships were compared to many different variables in the watershed to determine if there were any correlations that could be used to avoid having to do so many flow measurements to calculate a spawning or rearing flow for a certain fish species. The toe-width was the only variable found to have a high correlation. The toe-width is the distance from the toe of one streambank to the toe of the other streambank across the stream channel. This width of the stream is used in a power function equation to derive the flow needed for spawning and rearing salmon and steelhead (Swift, 1976 and 1979).

### **Instream Flow Incremental Methodology (IFIM)**

IFIM generally is selected as the best available method for predicting how the quantity of available fish habitat changes in response to incremental changes in streamflow. The U.S. Fish and Wildlife Service in the late 1970s (Bovee, 1982) developed this methodology. The IFIM involves putting site-specific streamflow and habitat data into a group of models collectively called PHABSIM (physical habitat simulation). Within IFIM are models of fish habitat as affected by hydraulics. The most common model is IFG4, which uses multiple transects to predict depths and velocities in a river over a range of flows. IFG4 creates a cell for each measured point along the transect or cross-section. Each cell has an average water depth and water velocity associated with a type of substrate or cover for a particular flow. The cell's area is measured in square feet. Fish habitat is defined in the computer model by the variables of velocity, depth, substrate, and/or cover. These are important habitat variables that can be measured, quantified, and predicted.

The IFIM is used nationwide and is accepted by most resource managers as the best available tool for determining, in a broad sense, the relationship between flows and fish habitat. However, the methodology only uses four variables in hydraulic simulation. At certain flows, such as extreme low flows, other variables such as fish passage, food supply (aquatic insects), competition between fish species, and predators (birds, larger fish, etc.) may be of overriding importance. In addition to the PHABSIM models, IFIM may include reviewing water quality, sediment, channel stability, temperature, hydrology, and other variables that affect fish production. These additional variables are not analyzed in this report.

After the IFG4 model is calibrated and run, its output is entered into another model (HABTAT) with data describing fish habitat preferences in terms of depth, velocity, substrate, and cover. These preferences vary according to fish species and life-stage (adult spawning and juvenile rearing).

The output of the HABTAT model is an index of fish habitat known as Weighted Useable Area (WUA). The preference factor for each variable at a cell is multiplied by the other variables to arrive at a composite, weighted preference factor for that cell. For example: a velocity preference of 1.0 multiplied by a depth preference of 0.9, then multiplied by a substrate preference of 0.8 equals a composite factor of 0.72 for that cell. This composite-preference factor is multiplied by the number of square feet of area in that cell.

A summation of all the transect cells' areas results in the total number of square feet of preferred habitat available at a specified flow. This quantity is normalized to 1,000 feet of stream or river. The final model result is a listing of fish habitat values (WUA) in units of square feet per 1,000 feet of stream. The WUA values are listed with their corresponding flows (given in cubic feet per second).

## **Tennant Method**

This methodology was developed by Don Tennant and predicts flows based on average flow. Using USGS data, this method is based on aquatic habitat being very similar when they are carrying the same proportion of the average flows. Ten percent of the average flow is a minimum instantaneous flow recommended to sustain short-term survival habitat for most aquatic life forms. Thirty percent is recommended as a base flow to sustain good survival conditions for most aquatic life forms and general recreation. Sixty percent provides excellent to outstanding habitat for most aquatic life forms during their primary periods of growth and for the majority of recreational uses.

In a large river, it can be useful in developing a quick response, such as for evaluating a water right application potential impacts.

### **Literature Cited**

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Swift III, C. H. 1976. Estimation of Stream Discharges Preferred by Steelhead Trout for Spawning and Rearing in Western Washington. USGS Open-File Report 75-155. Tacoma, Washington. (Toe-width)

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## Simplistic Comparison of Toe-Width and IFIM Flow Measurement Methods

Method	Purpose & typical use	Constraints	Advantages	Cost	Time	Equipment needed
<b>Toe-width</b>	<p>Generally used on smaller streams</p> <p>Describes 'peak habitat' for salmonids.</p> <p>This is a quick method for obtaining data to look at spawning and rearing flows.</p>	<p>Yields a single number for spawning and rearing flows (which makes it hard to balance between species and lifestages because it does not show the relationship between habitat and flow)</p>	<ul style="list-style-type: none"> <li>• Quick (several stream measurements (tails and ponds) can be taken in one day).</li> <li>• Easy (the method can be learned in an hour or so)</li> </ul>	<ul style="list-style-type: none"> <li>• Low cost per site (maybe an hour or two per site)</li> <li>• Most of the cost is the driving time to and between sites.</li> </ul>	<p>Can take as little as a week from data collection through write-up.</p>	<p>Minimal (measuring tape and a calculator)</p>
<b>IFIM</b>	<p>Describes "peak habitat" (sometimes called 'optimum') for salmonids.</p> <p>It provides data at various flow levels that can be correlated to what is the "best" habitat (i.e. flow, velocity, substrate) for fish.</p>	<ul style="list-style-type: none"> <li>• Relatively date intensive (have to visit each site at least three times at the appropriate flow stage.)</li> <li>• Takes a while (typically, because of the need for several measurements, it takes a week of field work spread over 3-4 months).</li> <li>• Specialized training is needed.</li> <li>• Timeliness is crucial—when measurements are taken is highly contingent on how fast stream flows are falling.</li> </ul>	<p>Generally recognized as "state of the art"—i.e., it is generally an accepted method of ascertaining flows needed for fish.</p>	<p>Relatively much more time intensive (more site visits; longer time to take measurements, run the model and write up the results).</p>	<p>Can take from six months to a year (flow measurements are needed for least three various stages of stream flow falling).</p>	<p>Relative to toe-width, much needed. Rod, velocity meter, tape measure, surveying level and tripod, survey rod; personal computer and IFIM program, boat and associated measuring equipment (if working in unwadeable streams or rivers).</p>